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The Continuation from Near to Far Field at Low Frequencies-

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An explicit formula is derived expressing the low frequency expansion of the far field coefficient for any radiating or scattered electromagnetic field in terms of the low frequency expansion of the near field. It is shown that a knowledge of a given number of near field terms suffices to determine the same number of far field terms, thus disproving the previously held contention that $p + 1$ near field terms were needed to determine p far field terms.

Lord Rayleigh provided a means for continuing the first term in the low frequency expansion of the near field into the far field (Philos.Mag., XLIV, 28 - 52, 1897) and A.F. Stevenson generalized Rayleigh's continuation procedure to include higher order terms (J.Appl.Phys., 24, 1134 - 1142, 1953). This method involves expanding the near field terms in spherical harmonics and matching the coefficients with near field representations of spherical Hankel functions. Since this is not necessarily a trivial calculation, unless the near field terms are already in this form, this procedure is not completely satisfying.

The most natural approach to the continuation problem makes use of the vector analogue of the Helmholtz integral representation of a field in terms of its values on a surface, where the surface field is expressed as a low frequency expansion. However, as observed by Stevenson, "the disadvantage of this procedure is that it is then found that to obtain even the first term in the series in the wave zone (far field) it is necessary to know two terms in the series for the surface field and generally to obtain p terms in the wave zone we must know $p + 1$ terms in the surface field. We thus lose accuracy in carrying through this procedure".

The present work shows how this criticism may be removed and that it is possible to accomplish the continuation of the near field into the far field using the natural approach based on the vector analogue of Helmholtz' theorem without requiring expansions in spherical harmonics and without loss of accuracy. The method described

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here owes its success to an apparently little known vector identity and a particular choice of the form of the vector Helmholtz integral representation. Though it must be possible to establish this result using any equivalent form of this representation, an unfortunate choice can make the required analysis prohibitively obscure, which apparently was the case in previous attempts.

Also included is a discussion of the first or Rayleigh term ^{the} in the far field scattered by a perfect conductor illuminated by a plane wave. Using the representation described above, it is shown that this term may be decomposed into two parts, one proportional to the volume of the scatterer and one, in a sense, proportional to the elongation of the scatterer, i.e. the difference between the volume of the scatterer and the volume of the smallest sphere enclosing it.